ABSTRACT

Implementation Intention as a Cognitive Strategy in STEM Education:
Assessing Pre-Algebraic Performance in 8th Grade Math Instruction

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Conceptualization of STEM has been a challenge due to varying perspectives within schools, school districts, and instructors. Implementation intention refers to a memory encoding strategy in which individuals explicitly specify retrieval cues to help them remember to perform goal directed actions. This study's objective was to examine if 8th grade STEM students would perform better on a math assessment compared to students in a traditional school after being trained to use implementation intention in a math lesson. Also, was there a difference in math performance between all students trained and not trained in an implementation intention strategy? Results from a 2 X 2 ANOVA and means scores indicated that there was a significant difference between schools and between trained and control groups; however, there was no significant interaction between the main effects. Effectiveness of implementation intention encoding suggests that it would be beneficial for educators to incorporate the strategy into instruction to produce self-regulated mathematical learners.

Implementation Intention as a Cognitive Strategy in STEM Education:
Assessing Pre-Aglebraic Performance in 8th Grade Math Instruction

by

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A Thesis

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CHAPTER ONE

Introduction

The United States developed as a global leader through the intellectual achievements of its engineers, scientists, and visionaries (Education for Global Leadership, 2013). In a world that is becoming increasingly multifaceted, the key to modernized success has now been driven to not only *what* you know, but by what you *can do* with what you know (Educate for Global Leadership, 2013). More than ever, it is essential for our youth to be prepared with proficiencies of problem solving, evaluating science evidence, and understanding the acquired knowledge for occupational application.

Americans began to raise awareness and concern in regards to the decrease in global advances following Russia's launch of Sputnik 1 in 1957 (Morrison & Bartlett, 2009). To initiate the goal of refining the disciplines of science, engineering, technology and mathematics, the National Aeronautics and Space Act of 1958 was created. The events sparked interest and led to STEM curriculum's establishment across the nation (Morrison & Bartlett 2009). In 2011, the United States was ranked 21st out of 30 organizations for the Economic Co-operation and Development (OCD) countries in science; furthermore, Americans were 25th as a country in the subject of math (Koonce et al., 2011). Concerning statistics have convinced our government leaders to take action. In addition to past investments, President Obama announced over $240 million in new private-sector commitments to inspire and prepare more girls and boys – especially those from underrepresented groups – to excel in the STEM fields (Education for Global

Leadership, 2013). With these progressive commitments, the President's "Educate to Innovate" campaign has involved over $1 billion in financial and in-kind support for STEM programs (Education for Global Leadership, 2013). Careers within these fields are in high demand of technical workers, engineers, and management related jobs.

What is STEM?

STEM refers to the curriculum targeting the disciplines of science, technology, engineering and mathematics. The nature of conceptualizing STEM has been a challenge for researchers over the years (Wasserman, 2015). Variations of the definition apply differently to various schools, school districts, and even instructors. The National Science Foundation (NSF) outlined the curriculum through two mechanisms (Koonce et al., 2011). First, STEM is a set of courses that pertain to core math and science courses that specifically target the STEM domains. Students enroll in *Calculus 1 for Engineering Majors* in replacement of general *Calculus 1*. NSF's second definition refers to the occupational aspects of STEM. Students receive direct exposure to the issues and topics within the pursued career paths they choose. Real world experiences are provided through projects in these elective classrooms. In conjunction, students potentially receive mentorship or guidance from professionals in the fields. STEM education also provides professional development opportunities for students in allowing them to practice giving presentations and working with colleagues.

To successfully outline STEM under NSF's two definitions, researchers must focus on the original goal of the movement, which is to provide a continuous reform of education through opportunities that create STEM-literate graduates. Students must be ready to accept the challenges of advanced education and essentials for the future workforce (The President's Council of Advisors on Science and Technology, 2010). In partnership with this mission statement, stakeholders must focus on providing funding, investment, and promotion towards STEM education. STEM is not simply science, technology, engineering, and mathematics as an individualistic construct, but an integrated approach to these studies (Matthews & Wolf, 2013).

Fully applying STEM curriculum at the elementary level is challenging due to the fact that students remain with one teacher for a large percentage of the school day (Roberts, 2012). Assimilation at the secondary level is more feasible because learning becomes continual and intentional in having more teachers and various elective classes. With more than one instructor, students are able to apply various learning techniques through different lesson plans. STEM's objective is to help students' learning experience by enhancing ability to transfer learning (Roberts, 2012). Students can solve innovative problems and form conclusions based on previously learned concepts applied through science, technology and engineering, and mathematics.

STEM increases motivation with inquiry-based learning, engages students and encourages them to solve authentic problems while allowing students to collaborate and build real-world solutions (Matthews & Wolf, 2013). According to a report by the website, STEMconnector.org, projections estimate the need for 8.65 million workers in the STEM-related occupations by 2018 (Hom, 2014). Manufacturing sectors are now faced with a shortage of employees with the necessary skills. The field of information technology alone would have created 1.7 million jobs between 2011 and 2015 (Hom, 2014). The U.S. Bureau of Labor Statistics projects that in approximately two years, the majority of STEM careers would include the following concentrations:

- Computing - 71%
- Traditional Engineering - 16%
- Physical Sciences - 7%
- Life Sciences - 4%
- Mathematics - 2%

These percentages suggest that it is crucial for American students to be qualified and knowledgeable to fit demands of the occupational market.

Instructional and Learning Reform

Teachers along with students must work as a team to promote the progression of the STEM disciplines. Instructors must aim to create an innovative and active learning environment. In return, students must branch out to receive experience and exposure with these subjects. By creating a strong foundation of science and math, students are able to apply learned concepts to the creative aspects of technology and science. Educators must study and teach through new lenses with the objective of expanding STEM curriculum development (Henderson & Dancy, 2011).

According to Fairweather (2008), “poor teaching practices in STEM courses appear to lie at the heart of some of these problematic trends” (p. 1). Poor teaching practices refer to failing to understand the causes of ineffective learning, resulting in low retention rates and negative effects on academic performance within STEM majors. Promotion and application of STEM subjects must first be given with effective learning or teaching approaches in mind. The reoccurring reason the curriculum fails to operate at its fullest potential is due to ineffective execution techniques used by teachers (Henderson & Dancy, 2011). Similar to most behavioral changes, the instruction and learning approaches to STEM disciplines takes time. Some instructors fail to apply the strategies due to issues such as lack of persistence or resorting to habitual teaching methods (Henderson & Dancy, 2011). Past empirical research has shown that student learning improves when instructors transition away from the traditional-style instruction to more student-centered, interactive, and applied instruction (Morrison & Bartlett, 2009). Although a large sum of time and money has been invested towards developing research-based curriculum, there currently is a substantial gap regarding knowledge of the best practice in instructional methods. The primary barrier to improving STEM education is not the of lack knowledge about effective teaching strategies (Henderson & Dancy, 2011). Explicitly, it involves instructors' lack of effectively understanding and applying new research-based tactics. Teachers must procure the knowledge, skill, and confidence to customize new strategies within their classroom settings.

Issues with Instructional Change

Past studies suggest that instructors may incorporate interactive learning, but often times without the peer interaction element (Henderson & Dancy, 2011). Teachers may have time constraints and feel pressured to reach performance requirements. As a result, teachers often resort to their traditional styles of instruction. This method allows teachers to streamline lectures and maintain a passive classroom while appearing to have applied research-based advancement (Henderson & Dancy, 2011). New college faculty reported that student-centered instruction was only confirmed by observations in about half of the cases (Henderson & Dancy, 2011). Faculty may have assimilated the ideas of student-centered instruction, but may not have effectively integrated the new changes. Researchers have referred to this inappropriate assimilation as adoption (Henderson & Dancy, 2011). Instructors, who believe that they have adopted an instructional strategy, but have inappropriately assimilated it into their prior instructional practices, may conclude that the strategy is ineffective. It is crucial for educators to be cognizant of their method of execution within the classroom environment to fully achieve the goals of STEM education.

Improving STEM

According to Henderson and Dancy (2011), there are four categories of educational change strategies that are based on the combined answers to two fundamental questions that emerged from analysis of past research:

- What is the primary aspect of the system that the change strategy seeks to directly impact; is it individuals or environments and structures?
- To what extent is the intended outcome for the individual or environment known in advance, prescribed or emergent?

The most effective reforms are likely to be found in strategies that allow for evolving outcomes as well as strategies that lead to structural changes (Bybee, 2010). Teachers must be interested in changing their instruction to initiate any form of improvement. In addition, instructors should seek to provide information, materials, encouragement, and assistance in helping other instructors as well. Henderson and Dancy (2011) have identified four change agents in helping instructors with the change process (see Figure

1). Although change measures typically function on the adoption or adaptation end, many faculty members apply various forms of reinvention as well (Henderson & Dancy, 2011). Educators potentially lack the expertise of education researchers and may develop materials in ways that are not consistent with effective outcomes. Such issues would often cause change agent results to discredit faculty as true reform partners and instead associate them as preventers of reform (Henderson & Dancy, 2011).

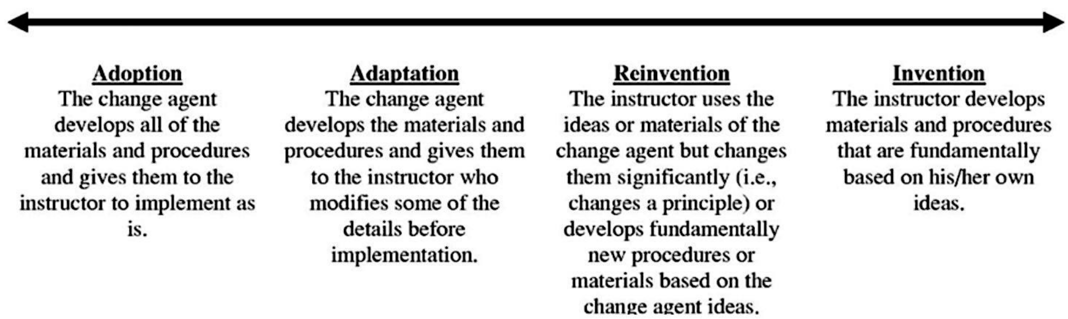

Figure 1.0. Adoption-Invention Continuum

Effective change agents involve creating and integrating active thought processes. When people encounter problems in translating goals into action, they may strategically rely on automatic processes in an attempt to secure goal attainment (Gollwitzer, 1999). One strategy that has been demonstrated in the literature to create automaticity is implementation intention encoding (Gollwitzer, 1997). Implementation intention plans follow the form of, "whenever situation *x* arises, one will initiate the goal-directed response, *y*." The strategy delegates the control of goal-directed responses (*y*) to anticipated situational cues (*x*), which frees attentional resources and allows responses to become more automatic (Gollwitzer, 1999).

In regards to education, implementation intention encoding could potentially be applied to help students cope with the challenging nature of STEM subjects. To effectively apply new learning strategies, teachers must incorporate the four change agents in the adoption-invention continuum: adoption, adaptation, reinvention, and invention. Without these considerations, progress with long-term effects will not be achieved. Possibilities of applying the encoding strategy in education settings may include using specific plans to memorize equations more sufficiently or assisting students with the order of operations in mathematics classrooms. For example, a student can form an implementation intention by stating, “When I see the parenthesis in a math problem, I will remember to solve that portion before exponents.” Next, the student would visualize himself or herself performing the intended task of solving the items in the parenthesis first.

The key difference between implementation intention encoding and rehearsal techniques is in the specificity (Liu & Park, 2004). By including “where” and “when” cues to the intended goal, one is able to strengthen the cue to action link by making the cue more accessible leading to automaticity. Achieving automaticity leads to a decline in cognitive demands. Moreover, the strategy would take less time and require less cognitive resources. With the numerous challenges students face with STEM concepts, forming implementation intention plans may be beneficial for students to use to their learning process.

A New Strategy

Change must occur in order to achieve educational advancement within STEM curriculum. Integrating implementation intention encoding could potentially contribute to the instructional reform efforts within STEM education. Implementation intention encoding refers to the goal achievement strategy in which a person converts the intention into specific context-linked plans. By connecting an intention to a particular context in specifying where and when it will be enacted, it leads to the prompting of intended actions and therefore increases automaticity (Gollwitzer, 1999).

With numerous studies that have suggested implementation intention encoding's effectiveness, American students struggling with STEM subjects as a whole could incorporate the strategy in their learning approaches. The curriculum contains challenging and cognitively demanding concepts. It would be beneficial for students to apply the encoding to their study habits if automaticity is achieved. For instance, if a student was struggling with memorizing a formula in reference to finding an area of a circle, they could use an implementation intention encoding by stating, "When I write the equation for an area of a circle, I will remember to square the given radius first after seeing the capital *A*." Students would then visualize what they had just verbalized. In doing so, the link to the cue and action will be strengthened achieving automaticity with learned concepts.

Implementation intention encoding provides goal directed responses of the *if x, then y* concept that can result in improved goal attainment, habitual and behavior changes (Gollwitzer, 1999). Previous studies have suggested that implementation intention techniques result in an effective link between goal and intention. For example, Luszczynska and Sobczyk (2007) found that twice the number of women from the ages of 18 to 76 years old assigned to an implementation intention treatment group, maintained long term results with their weight loss plan (p. 510). In addition to specifying when and where to act, forming plans regarding how to overcome anticipated barriers may result in larger effects of goal attainment. In doing so, participants were able to create self-regulatory habits in continuing goal pursuit. Company employees enhanced influence vaccination rates by applying implementation intention plans to help them remember to obtain influenza vaccination (Milkman et al., 2011). The results indicated that participants in the treatment group increased their total vaccination rates by nearly triple in comparison to the group without the specificity to their plans. Implementation intention encoding is beneficial to males and females and across a wide array of age groups (Liu & Park, 2004). Furthermore, there are over 1000 published implementation intention encoding studies to date suggesting beneficial evidence towards successful goal attainment.

Past research has provided evidence that automatic processes are less susceptible to age-related declines. The intended task was to help older adults remember to check their blood pressure in promoting compliance in improving medical adherence (Martin et al., 2005). Researchers in the study had the goal of generalizing the execution of the task from laboratory to naturalistic settings. Participants were asked to form a specific plan in which they explicitly specified when and where they could carry out the tests the next day and mentally imagined themselves carrying out the assigned tasks in those settings (Liu & Park, 2004). Past research has also indicated that automatic processes are less prone to age-related regressions, making it applicable to a wide range of individuals (Liu & Park, 2004). Researchers investigated whether the developments in older adults' memory for completing a laboratory task would generalize to a complex behavior in a naturalistic setting (Liu & Park, 2004). Results revealed that 95 percent of the participants remembered to at least check their blood pressure once a day using implementation intention plans outside laboratory settings.

Current Study

The current research will provide additional studies in regards to STEM education. The study may help teachers apply new learning methods to improve curriculum for 8th grade math students. STEM education is introduced to students in the form of a prerequisite elective to prepare students for high school objectives. Meeting benchmark-testing requirements is essential for students to advance to the next level of education. Furthermore, productively entering high school allows for greater college pursuit opportunities. Ranging from 13 to 14 years old, 8th graders developmentally enter the formal operation period in establishing logical thought, deductive reasoning abilities and improved memory function (Anthony, 2016). At the current stage of growth, 8th graders are able to utilize learning techniques such as mnemonics. Implementation intention encoding is a potential strategy that students could apply to learning STEM concepts.

Despite numerous years of effort and financial disbursements, there is little known about the collective impact of STEM curriculum in regards to academic performance and diverse populations of students (Labov et al., 2009). For instance, will more students pursue additional courses with previous exposure in STEM courses in comparison to students from more traditional classrooms? How are students performing in higher-level STEM courses? Are students able to apply concepts learned from one framework to another? With these questions present in the education field, the current study will explore differences between student performance in a STEM curriculum and a school without STEM curriculum.

Necessity for this study is driven by the responsibility to promote the mission of educational reform for economical advances. STEM education involves various learning approaches, creating blended learning environments and exhibiting application of learned concepts to daily life (Hom, 2014). The curriculum also attempts to recruit and motivate students in underrepresented populations. With the underrepresentation of females and minorities, it is essential for researchers to continue understanding and improving STEM curriculum outreach (Breiner et al., 2012). It is essential to study the benefits of applying implementation intention strategies in educational settings to assist students with cognitively demanding subjects. Hence, the current study will provide further information on the effects of implementation intention encoding for students struggling with challenging academic concepts. Creating self-regulated plans for learning processes such as memorizing mathematical conversion steps would be advantageous in various settings. Some examples would include the conversion of meters to kilometers or Fahrenheit to Celsius. Analyzing the effectiveness of applying implementation intention encoding to STEM students would be beneficial to empirically contribute to research in education. For non-STEM students struggling with mathematic concepts, applying implementation intention encoding would provide an additional encoding strategy to use in study habits. The following research questions will guide this study:

1. Is there a difference in mathematics task performance between students trained in an implementation intention strategy compared to students not trained?
2. Is there is an implementation intention encoding effect on math task performance between STEM students compared to students attending a

traditional school, and if so, is there an interaction effect between treatment and type of school?

CHAPTER TWO

Literature Review

Past studies have examined the effectiveness of STEM education or implementation intention, but there has been limited research exploring the relationship between the two. Researchers have worked to objectively define STEM, the issues that arise with it, and progressive benefits the curriculum provides for education systems. Implementation intention has been applied to assist with an assortment of human needs. With two strategic concepts, we analyze how the empirical history combines these ideas to help pre-algebraic performance in 8th grade students.

STEM Learning

STEM education targets problem solving and inquiry-based learning (Morrison et al., 2015). In mathematics classrooms, problem solving has become a focus of curriculum and instruction for the past three decades (Morrison et al., 2015). The goal of inquiry-based learning involves a student engaging in learning objectives that require profound thinking and solving non-routine problems. To acquire a contextual description of a STEM school, researchers examined the relationship between the school goals and actual classroom practice in relation to student achievement (Morrison et al., 2015). Orion High School's vision included collaborative work, social interactions, and problem solving-inquiry based approaches. To fill occupational demands across the United States, teachers and students must ensure a greater emphasis in higher order skills for a knowledge-driven economy (McNeill et al., 2008). A comparison would include innovation and creativity in preference to memorizing facts and repeating procedures. Social interaction between teacher and students were found to influence confidence levels in learning STEM disciplines as well. Supportive relationships and student cohesiveness have a significant influence on student motivation and self-regulation due to the communicative nature (McNeill et al., 2008). Collaborative learning assists with student learning and development of occupational skills beyond high school. Research in mathematics classrooms with collaborative learning suggests that learning in a well-constructed and facilitated groups can lead students to valuing multiple approaches and further understanding various concepts (Henderson & Dancy, 2011). In the specific study, researchers interviewed both teachers and students. Classroom observations, schools meetings, school design-planning efforts, student surveys, and standardized test scores were also analyzed in the current study (McNeill et al., 2008). Results suggest that the effectiveness of STEM curriculum contributed to student success in achievement and self-assessment. By creating a clear and objectified plan, the schools were able to utilize STEM education to its fullest potential. Incorporating problem solving based learning methods led to an effective and active learning environment. Teachers and students must work to enact an interactive partnership when studying cognitive demanding subjects.

Components of STEM

Researchers from the University of Cincinnati began STEM education's definition process by addressing who the main stakeholders were. Teachers, government officials, and business corporations are some of the examples of these stakeholders (Breiner et al., 2012). Depending on which perspective these individuals are adopting, STEM curriculum may change. For instance, educators may focus on replacing traditional lecture based teaching strategies with active learning environments. Corporate institutions or organizations may integrate STEM subjects through industry application for a working professional (Breiner et al., 2012). Other perspectives may involve using STEM as a motivating factor for graduating students within these disciplines. To examine various viewpoints, researchers gathered responses from faculty members from the University of Cincinnati (Breiner et al., 2012). Professors were asked to answer two free response questions: (1) What is STEM?, and (2) How does STEM influence and/or impact your life? Eighty-six percent did not understand the reference or misinterpreted STEM as a reference to other ideas. Twenty-seven percent replied with an unclear understanding of STEM's definition. Faculty participants reported answers to the second question through three different categories: null relationship to STEM, personal reasons, and societal issues (Breiner et al., 2012). Overall, survey results from university instructors in both STEM and non-STEM disciplines at UC suggest that even within the institutions of higher education where faculty members were extensively involved in multiple STEM projects and centers, there was no common operational definition or conceptualization of STEM (Breiner et al., 2012). The quality of the movement itself is negatively affected due to indefinite interpretations regarding the curriculum.

Research-Based STEM Programs

The literature has shown that a lack of effective mentoring and instructional methods are the causes of STEM education's insufficiency (Clark et al., 2015). To address such concerns, the NSF has been expanding their funding to research projects with the objective of better understanding ways of maintaining student retention and interests in STEM programs. An example included the Science, Engineering, and Technology Gateway of Ohio (SETGO). The program had a three-pronged approach to meeting various levels of needs for students in the STEM pipeline (Clark et al., 2015). SETGO was an extensive collaboration between a two-year community college and a four-year university. The STEM Summer Research Program and the Owens Ready Bridge have been found to be effective in significantly increasing students' beliefs and attitudes for both males and females in STEM programs (Clark et al., 2015). The study utilized a mixed-methods approach to further understand the causes for participant and program success. Participant responses were collected through the Science Attitude Survey (SAS), program observations, and interviews. The last approach involved was named the Art of Science (ASC). As an annual event that merged the SSR and OBR groups together, ASC allowed students the opportunity to learn about a STEM career and interact with scientists in the field (Clark et al., 2015). The study suggested that there was a correlation between the attitudes students had regarding particular subjects of STEM and performance within these programs. Researchers examined the relationship between the students' confidence in subjects they were learning to retention rates within the programs. In promoting confidence levels, students were able to explore various options and attempt to face challenges with STEM coursework. Results revealed a statistically significant increase in students' STEM confidence from pre to post regardless of program participation (Clark et al., 2015). Students must first understand the definition of STEM to fully apply the resources provided for them. Once an established understanding of STEM education was created by the three-pronged approach, students were able to explore career options, despite the challenging nature (Clark et al., 2015).

Implementation Intentions

Whether you are telling yourself to wake up earlier to finish a project or cutting back on calories after the holidays, following through with goal intentions can be challenging. Interferences, alternative choices or second thoughts, and temptations may be causes of failed goal attempts (McKay & McKay, 2012). However, particular goals we set for ourselves may sometimes lack the specific nature that leads to success. For example, one can have a goal of running at least one mile a day. Typically, one would state, "I will run a mile every day," but these individuals often fail to execute the goal. Alternatively, one could specify situational or contextual cues by stating, "After I brush my teeth tomorrow morning, I will go run a mile."

An implementation intention is a memory encoding strategy in which individuals explicitly specify retrieval cues to help them remember to perform goal directed actions (Liu & Park, 2004). Forming the specific plans enhance the activation and accessibility of intended actions for situational cues specified in the *if x, then y* case (Gollwitzer, 1999). An example one would state, "After I finish breakfast, I will remember to take my allergy medication." The strategy also creates a strong associative link between the thought of the cue and specified response, resulting in a task becoming more automatic (Gollwitzer, 1999). Compared to repetition techniques, implementation intention encoding does not require one to consciously intend to act in the critical moment. In other words, intended tasks would take less time due to the less effortful nature of implementation intention encoding. The strong associative links between the situational cue and the goal-directed response lead to automaticity, resulting in immediacy, productivity, and redundancy of conscious intent (Gollwiter & Oettingen, 2013).

Goal Intentions

Research reveals that implementation intention encoding has been an effective self-regulatory instrument used with overcoming obstacles associated with the initiation of goal-directed actions (Gollwitzer & Brandstatter, 1997). By forming specific plans, individuals are able to carry out goal intentions in a manner that is more automatic and require less cognitive demands. Self-regulatory habits allow for a more independent and successful process of forming and executing goals. Often times, people focus on the idea of the goal but neglect the formation of the goal intention. By creating *if-then* statements, one is able to seize appropriate opportunities to act towards his/her goal (Gollwitzer & Oettingen, 2013). In the conscious effort of creating the implementation intention plans, one is delegating control of goal-directed responses to present situation cues. Effects of implementation intention have been shown to help with goal initiation, staying on track, and avoiding resource depletion (Gollwitzer & Oettingen, 2011). By creating implementation intention plans, one is able to make the intended action more accessible to spontaneously retrieve information, leading to a higher chance of following through with the objective task (Gollwitzer, 1999).

Researchers have assessed implementation intention encoding by measuring completion rates of various goal-based projects through three experimental designs (Gollwitzer & Brandstatter, 1997). College students were first asked to form an implementation intention on when and where they intended to sit down and initiate their writing project over Christmas break. The holiday time contains numerous competing goals and external distractions. Some examples would include numerous family members present, holiday festivities, lack of motivation due to the nature of a break from school. It would be important to examine the causes of failure to initiate goal-directed actions (Gollwizter & Brandstatter, 1997). The following factors were measured in the study: importance, difficulty, and obstacles of goal completion.

In Study 1, participants were asked to identify two personal goals by listing projects that they intended to work on over the holiday break (Gollwizter & Brandstatter, 1997). Researchers wanted to examine what participants identified as “challenging” or “easy” tasks. Four weeks after Christmas break, participants were asked to complete a follow-up questionnaire answering whether or not they had completed the projects (Gollwitzer & Brandstatter, 1997). The relationship between the levels of self reported difficulty and actual completion of the goal was examined in the study (Gollwizter & Brandstatter, 1997). The results indicated that challenging goal intentions were completed approximately three times more frequently when participants applied implementation intention plans.

In Study 2, all participants were assigned the same challenging goal intention. Participants in the treatment condition were instructed to select a specific point in time and place to begin their writing assignment (Gollwitzer & Brandstatter, 1997). They were then asked to visualize themselves performing the task and to record the intended plan on an instruction sheet. Participants were instructed to mail in completed reports. The results revealed that 76% of participants in the treatment condition and 32% in the control condition completed their writing assignment suggesting a significant difference between treatment and control conditions (Gollwitzer & Brandstatter, 1997).

In Study 3, participants were assigned to one of three conditions, the treatment condition or two control conditions. The goal was to test the hypothesis of implementation intention encoding promoting immediacy of action initiation once the opportunities were encountered (Gollwitzer & Brandstatter, 1997). In the treatment group, participants were asked to express their viewpoints on a topic while watching a video. They were instructed to stop the video when an opinion needed to be stated. For each assertion, participants had the option to use the interlocutor to mark the point in time that they selected to input their viewpoint. After the marking, participants were instructed to form specific plans of when they would intervene or speak up in the next videos. Participants were limited to eight statements for each turn. Participants in the control groups were asked to either mark the points in the presented statements that seemed appropriate for the future or respond verbally to presented statements (Gollwitzer & Brandstatter, 1997). Following the video section, participants were asked to perform a distractor task of counting planes and various geometric figures (Gollwitzer & Brandstatter, 1997). Lastly, they were asked to recall as many arguments from the experiment as possible. The results demonstrated that implementation intention encoding led to immediate initiation of goal-directed behavior with encounters of distractions and anticipation of goal initiation (Gollwitzer & Brandstatter, 1997). Not only does implementation intention plans promote immediate action initiation, it also promotes task execution. In comparison to the two control groups, the treatment condition showed a significant difference with goal completion (Gollwitzer & Brandstatter, 1997). Participants in the treatment condition were able to approach the intended task through a more immediate nature when implementation intention plans were formed.

Though there has been empirical work on implementation intention encoding, there is limited research on applying the strategy in the education field. One study analyzed the progression of self-regulation strategies by combining implementation intention plans with mental contrasting concepts (Duckworth et al., 2011). Mental contrasting refers to a strategy that involves cognitive expansion of a desired outcome with relevant obstacles to the current objective leading to improved goal attainment (Duckworth et al., 2011). The study tested for effects of mental contrasting combined with implementation intention encoding with the objective of achieving successful goal application in adolescents. Sixty-six high school sophomores preparing to take a high-stakes exam in the fall of their junior year were randomly assigned to complete either a 30-minute written mental contrasting with implementation intentions intervention or a placebo control writing exercise (Duckworth et al., 2011). All participating students were assigned to complete a survey about the likelihood and importance of completing PSAT preparation procedures. At the end, students were asked to write two positive outcomes and two obstacles in regards to completion of the intended goal. In the treatment group, they were asked to rewrite the two positive and the two obstacle statements with more specificity by creating *if-then* implementation intention plans. Students in the control group were asked to write a short essay over an influential event or person in their life (Duckworth et al., 2011). Students in the treatment condition completed 60% more PSAT questions than students in the control condition. The results suggested that by applying mental contrasting and implementation intention plans, students were able to achieve their goals more effectively while obtaining a new self-regulatory strategy (Duckworth et al., 2011).

Forming an implementation intention encoding requires selection of a specific future situation. Therefore, the association between mental representation and the specific situation allows situational cues to automatically retrieve the intended (Gollwitzer & Ottingen, 2013). The increase in accessibility of the *if-then* part of the plan has been observed in several studies using various experimental tasks. Some examples include: cue detection, dichotic listening, cued recall and lexical decisions (Gollwitzer & Ottingen, 2013). Furthermore, Gollwitzer (1999) suggested that the effect of strong associative links between the *if*-part (situational cue) and the *then*-part (goal-directed response) created by forming implementation intentions is that once the critical cue is encountered, the initiation of the goal-directed response exhibits features of automaticity. Instances that involve implementation intention failures may include inadequately noticing opportune moments to act or noticing them too late due to a distraction. However, an individual may fail to execute a goal due to competing action tendencies stemming from strong impulses or undesirable habits (Baumeister et al., 1994). Additionally, intervention analyses suggest that both cue accessibility and the strength of the cue-response link, as a combination, determined the effect of implementation intentions on goal completion. Beneficial factors include efficacy, immediacy, and redundancy of conscious intent (Gollwitzer & Ottingen, 2013).

Application

Researchers have examined implementation intention encoding effectiveness through various forms of application (Powers et al., 2015). The encoding strategy has been shown to help women (18 to 76 years old) create a self-regulated weight loss plan and maintain long-term effects (Luszcynska et al., 2007). Participants were randomly assigned to either the intervention group or control group. Within the intervention group, women were instructed to create context-linked plans connecting the intention of attempting to lose weight to the particular context (Luszcynska et al., 2007). Women in the intervention condition achieved nearly double the amount of weight loss. Participants in both groups showed a reduction in BMI, but those in the intervention group lost significantly more with an average of 4.2 kg in comparison to an average of 2.1 kg in the control group (Luszcynska et al., 2007).

Implementation intention encoding has been shown to improve public health awareness by enhancing influenza vaccination rates (Milkman et al., 2011). Participants in the treatment group were asked to fill out a reminder card specifying the date and time of when the next influenza vaccination opportunity was to take place. In addition to the control group, the study also included a date plan condition that only required participants to generally include the date. In comparison to the control groups, participants in the treatment group had nearly three times as many onsite clinic visits (Milkman et al., 2011). The study revealed that by integrating a specific element into a reminder task, participants' vaccination rates increased significantly at no supplementary mailing cost.

Implementation intention encoding is applicable to all age groups, both male and female (Liu & Park, 2004). To assist older adults, the strategy was utilized to promote spontaneous retrieval. In the study, participants were randomly assigned to three experimental conditions: implementation intention group, rehearsal control group, and the control group. The treatment condition was instructed to specify when and where they would carry out the intended task of testing their blood pressure and to visualize them doing so. Older adults in the rehearsal control group were instructed to repeat their instructions to test their blood tests about 45-60 times. Lastly, the control group was asked to brainstorm the pros and cons of testing their blood sugar on a worksheet. The study revealed that 95% of the participants in the implementation intention group remembered to check their blood pressure at least once a day. Those in the rehearsal and control group reported a total of 68% and 73%, respectively (Liu & Park, 2004). The study revealed that since the strategy is not age-related, implementation intention planning benefitted a wide range of individuals by appealing to various needs and individuals. Over a three week period, approximately 50% more of the participants in the treatment group performed blood pressure tests on time compared to older adults who were assigned to the alternate groups (Liu & Park, 2004). Though more than half the rehearsal group participants reported to check their blood pressure at least once a day, stating the instructions about 45-60 times in comparison to the treatment group took much more effort and time (Liu & Park, 2004).

By creating associations of an intention with a specific future context (episodic simulation) intended tasks are more likely to be remembered and carried out (Liu & Park, 2004). Pre-experiencing the visual-spatial context in which the intention will later be performed may lead to enhanced cue-action association and deeper memory traces. As a result, this may lead to a reduction in strategic and cognitive attention to the specific intention. The effects could be helpful to students' learning processes with the challenging STEM disciplines.

Interference

Whether or not someone will be successful at long-term goal attainment is essentially dependent on confronting interferences. Temptations refer to an intended action conflicting with long-term goals due to its appealing nature (Kroese et al., 2011). For instance, a student could practice restraining from making common math errors but is tempted to resort to habitual tendencies. Sufficient literature has documented how the presence of temptations can disrupt goal attainment, specifically in situations where self-control resources are minimized (Baumeister & Vohs, 2000). Counteractive control theory suggests that temptations may promote rather than inhibit long-term consistent behavior. Fishbach (2000) proposed that temptations, signaling a threat toward long-term goals, automatically activate goal-directed behavior to avert the threat (p. 296). An example study suggested that when individuals were presented with tempting food items, their long-term goal to diet becomes increasingly accessible compared to a neutral control condition (Fishbach et al., 2003). Other studies in support of counteractive control theory have indicated that temptations improved the link of goal importance and intentions to diet (Kroese et al., 2011). A student may forget to carry the one over during a subtraction problem or solve for x before y. The quality of temptations people encounter is not easily responsive to change; therefore, future studies need to be conducted to find moderating factors in helping students improve temptation resistance (Fishbach et al., 2003). By forming implementation intention plans, one could replace the negative temptations with specific mental representations of the intended tasks.

Self-efficacy

Effects of interventions that target self-efficacy by formulating action plans were also studied in the context of fruit and vegetable consumption. Forming plans enables goal attainment by increasing automatic responses to cues (Luszczynska et al., 2007).

Empirical background has shown that creating planning interventions reveals improvement in behavioral changes. Consequently, Luszczynska et al. (2007) investigated whether an alteration in frequency of action planning may mediate the effects of the planning intervention on fruit and vegetable intake. Participants in the treatment group were first explained what self-efficacy was in relation to nutritional choices. Then, they were asked to recollect and write down a time when they effectively executed the intended nutritional goal. For instance, recalling a situation when they decided not to select a healthier beverage. Lastly, they were asked to create conditional statements of how, where, or when they would carryout specific nutritional decisions in a an incident with temptation present. Participants in the control group received a letter regarding the importance of seeking assistance when one fails to make positive nutritional choices. Subsequently, the control group revealed no significant changes whereas self-efficacy change mediated the effects of the intervention on change in fruit and vegetable intake. In addition, the study revealed that creating encoding plans resulted in effects that were found in a follow-up email 6 months later. The study revealed a strength of implementation intention encoding. Not only did the treatment help participants in increasing their fruit and vegetable intake, it also provided long-term effects for these individuals. If applied correctly, conditional plans have the opportunity to assist individuals with their short and long term goals.

Significance

Implementation intention plans are viewed as important techniques as well as components of more elaborate behavior change (Hagger & Luszczynska, 2014). Future planning concepts contribute to intentions becoming the primary cause of maintenance for long-term modification (Ajzen et al., 2011). Implementation intention encoding and action planning are two of the most commonly and frequently applied planning techniques adopted to alter human behavior (Adriaanse et al., 2011). Specific plans allow for the intention-behavior to apply to naturalistic settings and are low-cost. Above all, there is growing support for action planning effectiveness in prompting behavior change in health-related contexts as stand-alone intervention strategies or as part of more elaborate interventions involving multiple behavior change practices (Hagger & Luszczynska, 2014).

Implementation intention encoding has been shown to serve as an effective and cost-efficient way of promoting spontaneous retrieval and self-regulating behaviors amongst various populations (Milkman et al., 2011). Due to the prominent evidence that has improved healthcare, raised public health awareness, and medical adherence, it may be constructive to examine the effects of implementation intention plans within an education setting. With the challenges of STEM subjects, it could be beneficial to help students learn challenging concepts with or without the curriculum.

STEM was created to address U.S. economical and occupational issues that have existed for over 50 years. With the stigma of math and science concepts being difficult, several ways educators can change student perception is by teaching helpful study methods. Once students see improvement in their academic performance, they would be more likely to have a better perspective and self-efficacy with continuing to explore STEM disciplines. To better understand STEM curriculum, instructors must also work to actively understand and improve teaching techniques. In the current study, we examine the effectiveness of applying implementation intention encoding in pre-algebraic classrooms. It is essential that 8th grade students achieve a firm understanding of STEM learning objectives to further apply at the high school level and beyond.

CHAPTER THREE

Method

There is limited research that has examined the use of implementation intention encoding as a cognitive strategy applied in educational settings. The current study was designed to answer two main research questions. First, does math task performance differ between students trained to form implementation intention plans when compared to students who were not trained to do so? Second, do STEM students outperform students in a traditional school; and if so, does implementation intention training have a differential effect on students' performance between STEM versus traditional math classrooms? It was hypothesized that students' performance on a math task would be better for students trained to employ a relevant implementation intention. It was also hypothesized that the STEM classroom students would perform better overall compared to traditional students. Finally, it is also hypothesized that training in implementation intention encoding would benefit STEM students more than traditional classroom students.

Research Design

An experimental design was used to test the hypotheses. Two public middle schools were invited to participate; one school was a traditional middle school and the other a school following a STEM curriculum. Once recruited, participants were randomly assigned to either a treatment group (implementation intention training) or a group that received no training (control). Following training in implementation intention (or not) all participants responded to a math assessment covering math inequality concepts (see appendix).

Participants

A total of 143 participants from 8th grade, pre-algebraic classrooms were recruited in their second semester enrolled in two central Texas schools; one school follows a STEM curriculum, the other is a traditional suburban middle school. Students at the STEM school enter their STEM program by enrolling in an elective course. There were 33 students among three 8th grade pre-algebraic class periods that participated from the STEM school; at the traditional school 110 students among five 8th grade pre-algebraic class periods participated. The average age of participants was 15 years (SD = .50). Participant demographics at both schools are shown in Table 1.

Procedure

Once IRB approval for the project was acquired two schools were invited to participate; one was a traditional middle school and the other was a STEM school. IRB approval was passed as exempt, according to federal regulation. Administrators and math teachers at both schools were consulted about the research project, and permission to begin was granted. Math teachers sent participants home with protocol forms informing the parents of the study's procedure and purpose. In consultation with school personnel a date and time was scheduled for the experiment. Experiments were carried out at both schools and in all classes within one week of each other. The principle investigator worked with

Table 1

Participant Demographics

	STEM (*n*=33)		Traditional (*n*=110)		
Race	M	F	M	F	Total
Hispanic	8 (.24)	6 (.18)	9 (.08)	9 (.08)	32 (.23)
Asian	0	0	1 (.01)	2 (.02)	3 (.02)
Caucasian	2 (.06)	6 (.18)	22 (.20)	35 (.32)	65 (.46)
African American	1 (.03)	7 (.21)	9 (.08)	12 (.11)	29 (.20)
Other	1 (.03)	1 (.03)	5 (.05)	6 (.05)	13 (.10)
Total	12 (.08)	20 (.14)	46 (.32)	64 (.45)	142

Note. One participant did not respond to the item of race; parentheses contain parentages.

teachers to coordinate a class period and math concept for the experiment; the concept of math inequalities was selected as the math task to include in the experiment.

On the day of the experiment, the principle investigator delivered a 12-minute lesson over inequalities; the lesson was created in consultation with the math teachers. Key terminology and five example inequality math problems were written on the board as part of the lesson. A brief review of the definition and key terminology was discussed first. Following the review, the principle investigator worked through the example problems with the class by having the participants interactively answer the questions that checked for their understanding of example problems. All participants received the same inequalities math lesson in the same way with equivalent time on topic.

At the beginning of the day a research associate randomly assigned each class to either the treatment or the control group to control for experimenter bias during the math inequalities lesson. Thus, the principle investigator was blind to which classes would be assigned to the treatment or control until the conclusion of the lesson. Following the lesson by the principle investigator the research associate revealed to the principle investigator whether the class was randomly assigned to treatment or control groups. This resulted in the following groups: STEM school – 2 treatment groups and 2 control groups; traditional school – 3 treatment groups and 2 control group.

Treatment. If the class was randomly assigned to the treatment group the principle investigator wrote the following implementation intention encoding statement on the board: “When I divide by a negative number, I will remember to flip the inequality sign.” Then, the principle investigator read the intervention statement aloud to the class once. After the first reading aloud, participants were instructed to repeat the implementation intention statement written on the board three times out loud. Next, participants were asked to visualize performance of the statement for a total of 30 seconds, timed by the principle investigator. In a similar study, Luszczynska et al. (2006) examined the role of self-efficacy as it helped participants increase vegetable and fruit consumption. Participants were instructed to create situational plans of when they were going to perform particular actions that would help in their goal intention. Next, they were asked to write down their action plans. To enhance the effects of forming a situational statement, past studies have paired the creation of the statement with an additional task. In the current study, we wanted to test for effects when the follow-up activity was verbally stated instead of written down.

Control. If the class was randomly assigned to the control group, the principle investigator wrote the following statement on the board: "Flip the signs when dividing by a negative number." The principle investigator read the statement aloud to the class once. After the first reading aloud, participants were instructed to repeat the statement written on the board three times aloud. Then, participants were asked to visualize performance of the statement for a total of 30 seconds, timed by the principle investigator. The control activity was created in order to equalize the time both groups had to learn, but the treatment group was different due to the implementation intention encoding. The treatment required participants reciting the conditional statement of *if x, then y*. In contrast, participants in the control group recited a similar statement but without the situational cue component.

At the conclusion of the math lesson and activities in both groups, all participants completed a math assessment over inequalities (see appendix). A background survey was attached to the assessment asking for the students' month and birth year, sex, average time spent daily on math homework and the time participants went to sleep the night before; these two latter questions were asked in order to account for other factors that could affect performance on the math assessment (see appendix). Students were given 12 minutes to complete the assessment independently.

Scoring the math assessment. All math assessments were scored by the principle investigator blind to whether the assessment was from a treatment participant or a control participant as well as to school identity (STEM v. traditional).

Measures

The dependent variable in the current study was performance on a brief math assessment that contained inequality math problems (see appendix). The math assessment consisted of 14 math problems; Participants were given 12 minutes to complete as many items as possible. The number of items, 14, was chosen in order to avoid a ceiling effect. Of the 14 math problems 4 were "direct target" items – a math inequality item that required flipping the inequality sign. Another 4 items were inequalities but *did not* require the inequality sign to be flipped. The remaining 6 items were other math items related to the concept of inequalities. The math assessments yielded three separate data points for each participant:

1. Direct target dependent variable: Student participant solves the equation by dividing by a positive integer and correctly follows the division rule. Correct number of items where inequality sign was flipped. Figure 2 below provides an example.

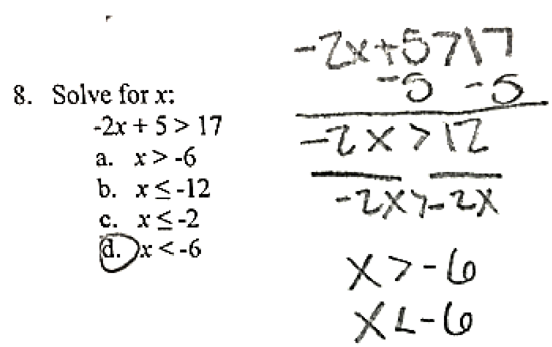

Figure 2.0. Direct target dependent variable

2. Indirect target dependent variable: Student participant solves the equation by dividing by a positive integer and correctly follows the division rule: Correct

items where inequality sign was not flipped. Figure 2.1 below provides an example.

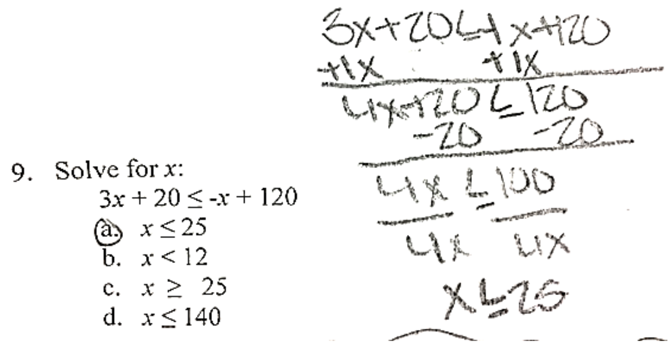

Figure 2.1. Indirect target dependent variable

3. Total number of correct items attempted.

In order to elicit some qualitative information from participants that may demonstrate whether being in a STEM school affects math concepts as applied, a portion of the math assessment asked participants to explain how answers were derived. One of the focuses of STEM education is to make workforce and worldly connections to concepts learned in the classrooms. The qualitative items were an opportunity to analyze differences between how students in the STEM school and traditional middle school integrated learned topics. Would STEM students be more efficient at providing explanations to problems since the curriculum centers on making connections to daily life?

Data Management and Analysis

Data Entry. Once all math assessments were scored a research associate randomly selected 10% of them (n=15) to confirm accurate scoring. The principle investigator created an SPSS data file and entered all quantitative data. These same 15 randomly selected assessments were checked for data entry errors once the SPSS data file was complete. In both math scoring accuracy and data entry checks there were no errors detected.

Analyses. Data analyses began by exploring descriptive statistics on all participant demographics and math assessment variables. To add validity to the use of the flipped inequality items as the target dependent variable of interest, a bivariate correlation analysis was run between flipped and non-flipped inequality items. To test the hypotheses of the experiment a 2 X 2 Univariate ANOVA was run in order to test for the main effects of GROUP (treatment vs. control), SCHOOL (traditional vs. STEM) and a GROUP X SCHOOL interaction effect; correct number of flipped items was used as the primary dependent variable. Beyond significance tests, post hoc power and effect size analyses were also investigated to address practical significance.

Given the great disparity in sample sizes between the GROUP and SCHOOL variables a violation of the homogeneity of variances assumption was a concern. In all ANOVAs, a Levene's test for homogeneity of variance was run to test for a difference between grouping variances; no significant differences were found. No significant differences were found with the covariates from the following variables from the background survey: month and birth year, sex, average time spent daily on math homework and the time participants went to sleep the night before.

CHAPTER FOUR

Results

Applying implementation intention in an educational setting is so far largely untested. However, it could represent a possible step in the direction of student self-regulation in school settings. In the current study, whether students were enrolled in a STEM or traditional school, the objective was to explore the effects of students' application of implementation intention encoding when solving math inequality problems; moreover, testing for performance differences between two distinct curriculums was also important in understanding differences. The following research questions guided the current study:

1. Is there a difference in mathematics task performance between students trained in an implementation intention strategy compared to students not trained?
2. Is there is an implementation intention encoding effect on math task performance between students in a STEM v. a traditional school, and if so, is there an interaction effect?

Descriptive Statistics on Math Assessment

Table 2 shows the average performance of all participants on all three math performance dependent variables. Flipped items are the most direct variable eliciting performance where the participants in the treatment group should have used the treatment of implementation intention encoding. Math items that do not require flipping the inequality sign are considered an indirect use of the implementation intention. The total represents all items correct that were attempted out of all 14 items.

Ancillary participant information revealed that participants reported spending an average of 30 minutes a day (*SD* = 16 minutes) doing math homework. The survey also asked what time the participants went to bed the night before; the median time was 10:30pm with a semi-interquartile range of 87 minutes.

Table 2

Descriptive Statistics on Math Assessment

	STEM (*n*=33)		Traditional (*n*=110)		
Items	Treatment (*n*=23)	Control (*n*=10)	Treatment (*n*=67)	Control (*n*=43)	Totals
Flipped	2.35 (1.3)	1.3 (1.2)	1.3 (1.2)	0.7 (1.0)	1.3 (1.3)
Not flipped	1.74 (1.1)	1.6 (1.1)	1.4 (0.9)	1.4 (0.8)	1.4 (0.9)
Total Correct	6.6 (3.0)	5.7 (2.6)	4.9 (2.6)	4.0 (2.6)	4.9 (2.8)

Note. The tabled numbers are number of items correct out of the following: 4 flipped items, 4 items not flipped, and total correct out of all 14.

Inferential Statistics and Tests of Significance

As stated above, a 2 X 2 ANOVA was used to test for main effects of GROUP and SCHOOL; a test of the interaction effect, GROUP X SCHOOL, was run to test the differential effect of the treatment by type of school. Prior to running the 2 X 2 ANOVA, the use of the dependent variable, "number of correct flipped items," was more firmly established as a valid measure by running a bivariate correlation between flipped items and non-flipped items for all 143 participants. The correlation analysis was followed by a 2 X 2 ANOVA using non-flipped items as a dependent variable instead of the flipped items.

Establishing the best dependent variable. The bivariate correlation between flipped and non-flipped items revealed a significant, positive correlation (r = .45, p < .01). This indicates that participants getting flipped items correct are also getting the non-flipped items correct (and vice versa). Given this significant, positive correlation between flipped and non-flipped items, a 2 X 2 ANOVA was run using non-flipped items as the dependent variable. This analysis revealed a significant main effect for SCHOOL (p < .05) but not for the main effect of GROUP or the GROUP X SCHOOL interaction. Following this analysis, number of correct flipped items was established as the primary dependent variable for use in the main 2 X 2 ANOVA to test the current study's hypotheses.

Main and interaction effects. As stated above a 2 X 2 ANOVA was run using number of correct flipped items as the dependent variable. The main effects of GROUP (treatment v. control), SCHOOL (traditional v. STEM) and a GROUP X SCHOOL interaction were tested for significance; p < .05 was used as the level of significance. As shown below in Table 3, there was a main effect of both GROUP and SCHOOL. However, there was not a statistically significant GROUP X SCHOOL interaction (see Table 3). Cohen's *d* effect sizes were computed and also reported in Table 3 for the significant main effects. As shown there, the effects sizes demonstrate a moderate effect on the flipped items. The post hoc power analysis for both main effects indicated 1-β = .48; this represents a reasonably powerful research design and test of significance.

Summary of quantitative analyses. The statistical analysis of the data reveals several findings. First, treatment group participants, those receiving the implementation intention, significantly outperformed the control participants on the math inequality items that required flipping the inequality sign. Second, STEM school participants outperformed the traditional school participants on both the flipped and non-flipped inequality math items. Finally, there was no significant interaction effect between the treatment effect and the type of school. Thus, overall the data suggest that implementation intention has a positive effect on related math items, and STEM school participants have an advantage over students following a traditional curriculum.

Table 3

GROUP X SCHOOL ANOVA Source Table

Source	SS	*df*	MS	*F*	Sig.	Cohen's *d*
Group	14.1	1	14.1	9.7	.002	.48
School	14.2	1	14.2	9.8	.002	.48
Group X School	1.3	1	1.3	0.9	.338	
Error	201.5	139	1.5			

These outcomes of the 2 X 2 ANOVA along with the means reported in Table 2 indicate that participants in the treatment groups at both schools performed better on the target items than their control counterparts. These results also indicate that there is a significant main effect for SCHOOL in that the STEM school participants outperformed the traditional school participants. Finally, this analysis indicates that there is no significant interaction effect; in other words, the treatment affects performance as does the school attended, but the treatment effect does not depend on or exert a differential effect in one school over the other. As shown in Figure 3, the lines are not parallel. Figure 3 visually clearly demonstrates the two main effects for groups (treatment v. control) and school (STEM v. traditional). Participants in the treatment group at the STEM school had the highest average of correct attempted questions comparatively. Participants in the control group at the STEM school had a higher average amount of correct attempted compared to participants in the treatment or control at the traditional school.

Qualitative Results

After every few questions throughout the assessment, open response questions were included after the calculation item. The open response section was included to investigate participants' understanding of the concept. Mathematics education has been incorrectly defined as limited to being solely a calculation based on subject (Boeler, 2016). However, the true construction of the subject matter should be the study of various calculations and the meaning behind them in relation to naturalistic functions. There were

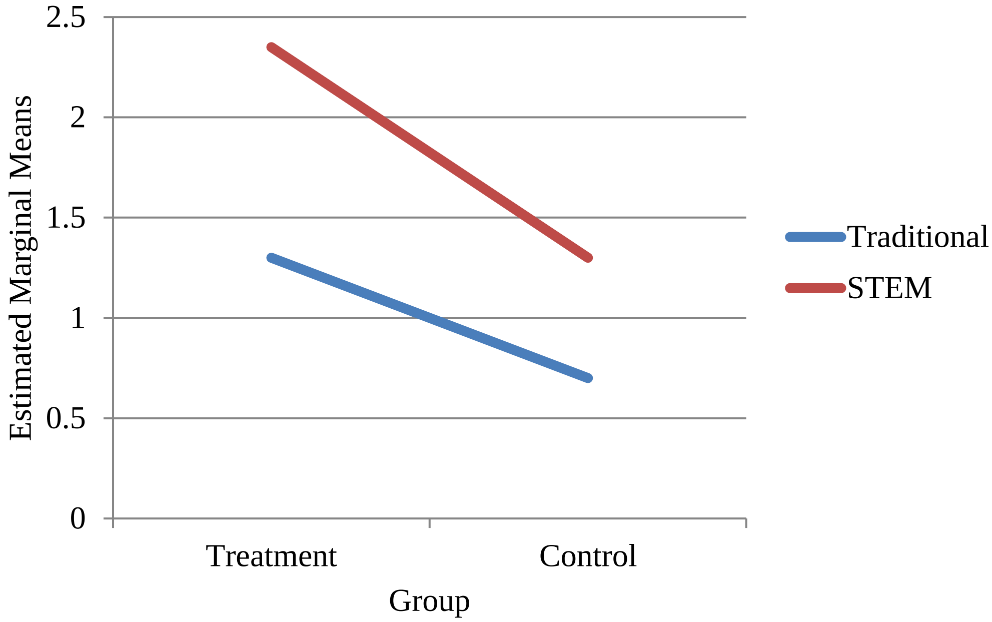

Figure 3.0. Estimated Marginal Means of Direct Target Items Correct

two themes generalized from participant responses in the assessment. The majority of participants were unable to explain correctly why they constructed their answer. Many answered with an "I don't know" or an equivalent statement. Despite answering with an incorrect or correct answer, most participants were not able to explain their understanding or the meaning behind their calculation. Those who were successful performing the calculations were able to write into text format the performed calculation above. As far as why they performed each step, participants would answer with statements such as, "my teacher told us to do so" or "I don't know, that's just how you solve it." These qualitative responses did not reveal an understanding of the learned mathematic concept

CHAPTER FIVE

Discussion

The objectives of the current study were to explore differences on math performance between 8th graders following a STEM v. traditional school curriculum and to investigate whether implementation intention made a difference in their performance. Research suggests that when teachers and students work collaboratively to integrate curriculum modifications, such as incorporating implementation intention, student performance may increase, and ultimately students may come to change their perceptions of their own abilities. Indeed, Clark et al. (2015) conducted a study of increased student confidence levels by introducing summer programs such as SETGO. The program worked as a partnership of a community college and a four-year university. The goal of the program was to allow students from both institutions to explore the STEM subjects and meet to share their viewpoints amongst one another. Here educational leaders took initiative to create an avenue for teachers and students to share their STEM experiences. Students were able to explore various career options and attempt to face challenges with STEM coursework. Results revealed a statistically significant increase in students' STEM confidence from pre to post regardless of program participation (Clark et al., 2015).

Previous studies have revealed that by introducing a simple *if x, then y* statement (implementation intention) after an activity, participants were more likely to execute intended tasks compared to those who did not create an implementation intention statement. Researchers have assessed implementation intention encoding by measuring completion rates of various goal-based projects through different experimental designs

(Gollwitzer & Brandstatter, 1997). Gollwitzer et al. (1997) worked with college students to test for implementation intention effects on completing assignments. Participants were first asked to identify assignment goals over their winter break due to the distracting nature of the holiday time. Then, students were asked to form an implementation intention on when and where they intended to sit down and initiate their writing project over Christmas break. Results indicated that challenging goal intentions were completed approximately three times more frequently when participants applied implementation intention plans.

The current study adds to the literature with empirical support that implementation intention positively affects student performance in a pre-algebraic 8th grade math concept. However, in the current study, implementation intention encoding targeted a specific step in solving a particular concept. Selecting specific opportunities to initiate goal-directed responses involves people anticipating situations in which the execution of goal-directed responses will occur (Gollwitzer & Sheeran, 2006). The cues can either be related to suitable opportunities to execute or to address anticipated obstacles to goal striving. Cue selection can help students focus on instigating and ensuring the goal striving or on shielding it from particular anticipated obstacles. Consequently, students are prompted to be more organized and prepared with their learning methods.

Creating implementation intention plans allow students to identify instances where they can execute the goal. Teachers may help students brainstorm occurrences that lead to common math errors. Alternatively, a group activity assigned for students to work collaboratively in creating these plans is another opportunity for teachers to explore the strategy. For instance, students create an encoding plan to help with remembering the first step of solving an equality equation. If the equation requires the students to subtract 5 from both sides first, yet they divide instead, that would lead students to immediately start the problem incorrectly. Perhaps, students have incorrectly primed themselves to remember that each time they see a number and variable pair such as *2x* to divide first. However, forming an implementation intention plan may serve as a reminder that *x* needs to be isolated first before dividing. Thus, cue selection through the process of a goal attainment must be implemented correctly.

Demographic Differences Between Schools and their Participants

Before discussing the findings and their contribution to the literature, the demographics of both schools and the participants will be addressed. From an SES standpoint, the traditional school is a middle-class, suburban school. The STEM school is an urban school in a lower middle-class neighborhood. Given these SES differences it is important to consider the participant demographics as they may differ between schools and represent a confounding variable. Despite the ostensible SES differences between schools, there was a reasonable amount of parity across racial demographics represented in the samples from both schools. Both participating schools had similar numbers of Hispanic, African American and Asian participants. However, as expected, there were more Caucasian participants at the traditional school in comparison to the STEM school. Interestingly, even though the STEM school was considered to be part of the lower SES, participants in the school performed with higher accuracy. Finally, while there were more female participants this was true across both schools. Therefore, the reader should keep in mind the SES differences in mind as these findings are discussed.

Effects on Performance

The first research question tested for differences in mathematics task performance between students trained in an implementation intention strategy compared to students not trained. These outcomes of the math assessments along with the means reported in Table 2 indicate that participants in the treatment groups at both schools performed better on the target items than their control counterparts. The results indicate that effectiveness of the treatment was not dependent on the school type. If the school type does not affect the treatment, applying implementation intention encoding to any 8^{th} grade curriculum will be contributable towards helping students with mathematical learning.

Implementation intention encoding is beneficial towards successful goal intention due to its increasing of commitment and application of the goal (Gollwiter & Oettingen, 2013). The first part to completing a goal is forming a strong commitment or reason to initiate the goal. Instructors promote the first part by introducing and explaining concepts within the classroom settings. The next part must include a plan regarding the execution of an intended task. To help students become more sufficient with learning, implementation intention encoding could assist in addressing potential critical situations. For instance, students know that if they are left with $3x < 6$ in an equation, they are supposed to divide both sides by 3 yielding the solution, $x < 6$. However, if the remaining equation was $-3x < 6$, the student would need to remember to flip the inequality symbol. In defining when and where to execute the goal intention of flipping the inequality symbol correctly, students can use the implementation intention encoding statement taught to them. Additionally, knowing that they have techniques such as these statements to assist in remembering when and where to perform a specific action could help address math anxiety issues. Selection of a critical future situation heightens the activation and accessibility of the mental presentation of the cue specified in the *if*-component (Gollwitzer & Oettingen, 2013). Forming implementation intention plans creates a strong associated-link between the cue and intended response, allowing students' to perceive learning math as a more attainable goal.

The second research question inquired if there was an implementation intention encoding effect on math task performance, does it matter whether the students are in a STEM school curriculum vs. a traditional school? Results indicate that there is a significant main effect for school type in that the STEM school participants outperformed the traditional school participants in all three dependent variables of the math assessment. The STEM school, located in a lower SES neighborhood (unlike the traditional school), would typically not be expected to perform with more correct answers. The data here show that to be the case, however. Indeed, research suggests that integrating more STEM programs within schools could be beneficial towards education reform (Hom, 2014). Sizeable financial investments such as the President's "Educate to Innovate" campaign should motivate educators to ensure that the curriculum is as constructive to students as possible (Education for Global Leadership, 2013). Students in the STEM curriculum are challenged and taught through new perspectives (Brown et al., 2011). STEM education has been defined as a standards-based, meta-discipline administered through an integrated approach of teaching and instruction, where discipline-specific content is not divided but addressed and treated as one fused study (Merrill, 2009).

According to Merrill (2009), "STEM teaching and learning focuses on authentic content and problems, using hands-on, technological tools, equipment, and procedures in innovative ways to help solve human wants and needs" (p. 6). STEM education often requires collaboration, since teachers have not been trained in STEM areas outside of their specific discipline; however, Merrill (2009) reports little collaboration occurring. Approximately 90% of the participants stated that they do not collaborate with peers in STEM areas. When the responses of those who stated that they do collaborate with peers in STEM areas were examined along with the number of participants who understand STEM education, it made up less than 20% of the participants. While a number of teachers understand and value STEM education, few apply it (Merrill, 2009). The implication is that in order for STEM education to become a reality, those who understand and value it must find like-minded peers with whom to collaborate and implement it. The issue may require an awareness-raising effort on the part of the teacher who wishes to truly implement STEM education. It would be beneficial for teachers to share effective strategies that are feasible to perform within various lesson plans. Implementation intention encoding is applicable to all math concepts whether the teacher is directing the encoding or the students are independently forming the plans.

To help improve the learning process, it is crucial that teachers be informed of applicable resources or techniques. STEM curriculum was created to also produce workforce ready individuals. Graduates should be trained to think critically and effectively; in other words, producing students who are STEM-literate (Matthews &

Wolf, 2013). When challenging tasks and projects arise, STEM-literate graduates would be able to formulate independent solutions. In the current study, participants' written responses on the assessment revealed that they did not fully grasp the meaning behind their calculations. Further studies should not only continue addressing accuracy on math assessments but also understanding of concepts. In doing so, strategies used to learn STEM subjects allow individuals to transfer what they have practiced in the classrooms to the working world.

Inequalities

The current study is noteworthy because it is one of the first to integrate implementation intention encoding to educational settings and test its effect experimentally. Specifically, the experiment was conducted within naturalistic settings (i.e., classrooms) focusing on a pre-algebraic concept, solving inequalities. Other researchers have tested for implementation intention effects but primarily in a laboratory-like setting. For example, in a similar study, participants were asked to create a written encoding statement of when and where they would check their blood pressure in a laboratory setting (Liu & Park, 2004). Participants were then asked to visualize performing the intended task. Consistent to the findings in the current study, participants proved to significantly improve in regards to goal intentions. Participants were asked to verbalize the statement from the board in the current study. Further research should examine how implementation intention encoding differs from written and verbalized statements. Results from the current study were also consistent with components of the counteractive control theory. Studies in support of the theory have indicated that temptations improved the link of goal importance and intentions to diet (Fishbach et al., 2003). Participants in the current study may encounter the temptation of circling the answer immediately after the final division process. However, integrating implementation intention helps to automatically activate goal-directed behavior to prevent the interference of unintended actions.

Implementation intention encoding would allow teachers to customize and refine the technique to various contexts as part of the reinvention stage of the adoption-invention continuum (Henderson & Dancy, 2011). Introducing a change agent in any setting could take time for teachers and students to become accustomed to it. However, with the sufficiency in time and resources, both groups are able to integrate to classroom concepts speedily. With the improvement found in the assessment performance in the treatment groups, implementation intention encoding has the potential to provide students with an opportunity to be self-regulated learners. Once they have practiced the encoding strategy within the classroom, they could form statements while studying or doing homework. Often times, when students study for examinations, they review by memorizing as much information as possible. However, implementation intention provides a way for students to learn concepts intricately in the creation of encoding plans. Information will be stored and become more accessible in comparison to strictly memorizing and repeating information. Moreover, students at all levels of comprehension of the topic could use the strategy. Implementation intention encoding has the potential to be customizable towards different varieties of goal intentions. Women from the ages of 17 to 86 used implementation intention prompts to better maintain or initiate a weight loss intervention (Luszczynska et al., 2007). Implementation intention plans are a form of action planning and has been discovered to mediate intention–behavior relationships

(Luszczynska & Schwarzer, 2003). Implementation intention constructions encourage participants to engage in more frequent, specific action planning (Luszczynska, 2006). Complex tasks are likely to benefit from recurrent action planning since required action may change over time in various environments. Students may not have the same teachers are they advance through the grade levels. However, with proper practice, students have the opportunity to excel no matter where they are in mathematical comprehension. One student may be struggling with a unit over financial literacy and a classmate may not. However, one can ensure that using implementation intention encoding helps with remembering steps in solving a complex equation. The classmate who was not struggling can also apply prompted plans to maintain or avoid making careless errors in the future.

Students who are struggling could create implementation intention plans to help remember how to begin solving the problem. Students with an average performance could apply the plans to prevent them from making common errors. Implementation intention is applicable to not only students at every level but for various uses. For example, a student could be balancing all the equations correctly but still not scoring higher than a B average since they forget to flip the inequality symbol for the negative numbers. The low cost and ease of integration makes implementation intention an ideal learning option for students with or without the STEM curriculum.

Limitations

There were several limitations that are worth noting in the current study. First, there was a large disparity in sample sizes between schools. Though statistically tested for variance equivalency, from a research design standpoint one would want more equal representation between schools. The current study lacked this equivalency and thus limits the generalizability of the findings and warrants caution interpreting the findings. Future testing should involve a larger and more equivalent sample size from both types of schools. A next step would be to compare several STEM schools to see how the students within these programs apply implementation intention.

A second limitation is the focus on only one outcome, a pre-algebraic concept, in a short term performance. Future research should expand the outcome variables to other learning outcomes in order to better understand the short and long term impact of implementation intention. Another option would be to not only have teachers deliver the encoding statements but also have students create their own. The direct application (flipped) proved to effectively help students execute the intended action of flipping the inequality symbol in the last division step. However, future studies should examine how indirect manipulation of implementation intention encoding could be improved as well.

A final limitation and one already noted is the lack of SES equivalency between the two schools. While the higher performing school, a STEM school, turned out to be the low SES school, one must be cautious drawing the conclusion that STEM school students in general outperform traditional schools students even with low SES students. The current study did not directly measure SES; the STEM school volunteered participation and given its geographic location, is assumed to be of lower SES compared to the suburban traditional school.

General Conclusions

In light of the limitations listed above along with others that come with conducting research in the school setting, the current study does reveal some findings suggesting some overall conclusions regarding implementation intentions in the teaching of school concepts and the comparison of STEM v. traditional school curriculum. First, there is evidence that implementation intention encoding following instruction is beneficial to students' performance on a math assessment. Second, one can cautiously conclude that students in the STEM school were better prepared to perform the math task following the brief lesson. Finally, the implementation intention strategy does not appear to vary or differentially exert its effect depending on being placed within a STEM or traditional school curriculum. In the end, it seems that implementation intention may join other strategies employed by teachers and students as the work of school learning commences. It is positively worthy of more investigation.

APPENDIX

APPENDIX A

Student #: __________

Survey:

Please fill out this survey:

1. What month were you born? _____________________

2. What year were you born? ______________________

3. Please circle the racial category in which you closely identify:

   A) Latino

   B) Asian

   C) White/Caucasian

   D) Black/African American

4. What is your sex?

   A) Male

   B) Female

5. On average, how long do you spend on math homework daily?

   A) 0 minutes

   B) 30 minutes

   C) 1 hour

   D) More than 2 hours

6. What time did you go to sleep last night? ___________

Assessment:

You will have 12 minutes to complete this assessment. Please work independently and try your best.

1. Solve for y:
   $6y + 2 < 14$
   a. $y > 7$
   b. $y < -2$
   c. $y < 2$
   d. $y < 6$

2. Four minus three times a number is greater than two times the number minus one. What is the solution?
   a. $x > 5$
   b. $x < 1$
   c. $x > 3$
   d. $x > 1$

3. Solve for y:
   $5 - 2y \geq -3y - 6$
   a. $y \leq 11$
   b. $y \geq 11$
   c. $y \leq 2$
   d. $y \geq 6$

For question 3, explain how you solved for y.

4. Sam has twice a number and increased by five is greater than three times the number minus three. What should Sam write for this equation?
   a. $5x + 2 > 3x - 3$
   b. $2x + 5 > 3x - 3$
   c. $2x + 5 < 3x - 3$
   d. $10x > 3x - 3$

5. Solve for x:
   $48 + 2x < 42 + 3x$
      a. $x > 12$
      b. $x > -6$
      c. $x > 6$
      d. $x > -12$

6. Five times a number is increased by 4, the answer is at least 19. What is the solution if x was the variable?
   a. $x \leq 3$
   b. $x \leq 2$
   c. $x \geq 3$
   d. $x \leq -3$

For question 6, explain how you solved for x.

7. X is at most 20. Write the inequality for X.

8. Solve for x:
   $-2x + 5 > 17$
   a. $x > -6$
   b. $x \leq -12$
   c. $x \leq -2$
   d. $x < -6$

9. Solve for x:
   $3x + 20 \leq -x + 120$
   a. $x \leq 25$
   b. $x < 12$
   c. $x \geq 25$
   d. $x \leq 140$

10. Solve for x:
    $-3x - 8 \geq -26$
    a. $x > 5$
    b. $x \leq 6$
    c. $x \geq 6$
    d. 0

For question 9, explain how you solved for x.

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11. Heather is helping her friend solve this inequality equation: six plus three times a number is less than two times the number plus seven. Which of the following is the equation she needs to write down
    a. $3x + 7 > 3x - 2$
    b. $6 + 3x < 7 + 2x$
    c. $x + 5 < 6x + 1$
    d. $6 + 3x > 7 + 2x$

12. Negative five times a number minus six is less than four times the number plus three. What is the solution for x?
    a. $x < -1$
    b. $x > 3$
    c. $x > -1$
    d. $x < 3$

For question 12, explain how you solved for *x*.

13. Solve for *y:*
    $4 + 5y \geq 5 + 3y$
    a. $y \geq ½$
    b. $y \geq 2$
    c. $y \geq 15$
    d. $y \geq 1/3$

14. Plant A is 5 centimeters tall and growing at the rate of 3 centimeters a month. Plant B is 4 centimeters tall and growing at the rate of 5 centimeters a month. When will Plant B grow higher than Plant A?

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